1. ENVIRONMENTAL SITE INVESTIGATION IN CROATIA AND THE CONCEPTION OF THE ENVIRONMENTAL AND INDUSTRIAL HEALTH HAZARD RISK FRAMEWORK FOR DEPLOYED CANADIAN FORCES

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INTRODUCTION

The modern battlespace encompasses many hazards to life and health. In addition to the obvious risks from the action of belligerents and naturally occurring hazards such as those caused by climate and endemic disease, current patterns of deployment carry the additional risk of potentially harmful exposure to chemical, biological and radiological hazards within the man-made environment. Acute or chronic exposure to these hazards may result in adverse health effects to military personnel and could have an impact on Canadian Forces operational capability. "Eco-terrorism" or the intentional dispersing of chemical, biological or radiological material can further increase these risk to exposure and represent a definite area of concern that must be predicted and properly evaluated in a timely manner.

Canadian Forces personnel serving with the United Nations Protection Force (UNPROFOR – OP Harmony) in Croatia initially raised the possibility that troops had been exposed to contaminants in 1993-1994. The concerns at the time focused on the potential exposure to polychlorinated biphenyls (PCBs) and bauxite - used to fill sandbags for defensive works. Unfortunately, these concerns were never confirmed or fully investigated with proper closure, as they were not well understood by the operational planners at that time. Subsequently, the need to characterize environmental hazards was emphasized in 1998 when allegations were made that unexplainable illnesses being reported by Canadian Forces Personnel were as a result of being unknowingly exposed to environmental contaminants while in Croatia. These allegations prompted a review of all available documentation dating back from 1993. It was at this point that it became clear that no scientifically defendable information could be found. As a result, an environmental investigation team was sent to Croatia in July 1999 in an effort to determine the presence of environmental contamination that could explain the reported illnesses.

METHODS

In the four years or more timeframe between the investigation and the last presence of Canadian troops in the area of concern, many site conditions had changed, making it difficult to obtain truly representative samples. Most of the Canadian sites were observation posts positioned on mountain summits or along ridges removed from built up areas and industry (Map 1). In many cases, access to the sites was limited; some locations could not be reached due to the existing mine threat or impassable roads. Another limitation to the environmental study was that non-persistent contaminants would have undergone natural attenuation and volatilization, and contaminants in the air and water would have migrated away. Therefore, a forensic sampling approach was taken to screen for persistent contamination and degradation products at the locations occupied by Canadians. Environmental forensics is an evolving discipline virtually unheard of five years ago. The practice is used increasingly frequently to help investigators gain a better understanding of the nature, extent, ownership, and allocation of site contamination. Environmental forensics was applied in Croatia to discover whether any contaminants were present at sites where Canadians were serving during Operation Harmony, and if so, to determine whether persistent contaminants were present at

concentrations that could result in adverse health effects. Background samples were also collected in areas free from any localized contamination to provide a reference for determining whether targeted samples had significantly different levels of contaminants.

Although the concerns were centered on PCBs and bauxite, analyses were also performed for a wide range of persistent chemicals, by-products, and radioisotopes. The analytical program was developed which included both screening and specific analytical approaches. A strict quality assurance/quality control program was established to ensure that the data would be accurate and representative of actual conditions. Details of the analytical program can be found at Table 1.

RESULTS AND DISCUSSION

Despite the exhaustive analytical program, only a few selected metals (arsenic, cadmium, zinc, vanadium, and chromium) were found in concentrations exceeding Canadian soil quality guidelines for the protection of human health and there was very little evidence of organic chemical contamination (Table 2). It was later determined through a qualitative risk assessment that these levels were deemed not to be a risk to human health. Despite the lack of persistent environmental contaminants, the links between service in Croatia and health problems were observed. Furthermore, the possibility of exposure to other more volatile soil contamination and other form of water-borne, air-borne or transient contamination could not be ruled out. In the end, the results of the environmental forensic study were presented to a formal Board of Inquiry (BOI).

Over a 6-month period, the Board interviewed Op Harmony veterans and discovered that many had a variety of unexplained medical conditions, many of which had not been reported for fear of jeopardizing their military careers. The Board also observed that one of the major differences between OP Harmony and other Canadian UN and NATO missions between 1960 and 1993 was the intensity of the conflict area. It became clear to the Board that during the early events of OP Harmony, many of the Canadian soldiers lived under constant combat conditions and were frequently caught in the crossfire between the warring sides; at times even becoming targets themselves. Coincidentally, the Board observed that others who fought in previous high intensity conflicts over the ages reported many of the same symptoms as reported by OP Harmony veterans. This testimony led to identify stress as a probable major cause of the illnesses reported among soldiers who served in Croatia. Experts have described combat stress reaction, not as a new phenomenon, but as a very old one. Combat stress reaction has been documented among veterans of conflict in other military forces of other generations. For example, records show that for more than 300 years soldiers have reported a mysterious range of physical symptoms. In the end, the Board concluded that the health problems reported by OP Harmony veterans were from what appears to be stress-related ailments. However due to the forensic nature of the environmental study, only persistent contaminants could be were ruled out. It is doubtful that the cause will ever be identified for certain.

RISK FRAMEWORK

In the interests of preventing exposure to harmful contamination during future missions, it was recommended by the BOI that the Canadian Forces take measures to identify, characterize and predict risks from environmental and industrial health hazards (EIHH) and public health concerns (PHC) on deployed operations. This may include such hazards as: toxic industrial chemicals, pathogenic organisms, and radiation hazards from Release Other Than Attack (ROTA); public health threats such as disease vectors; and, physical hazards such as dust, smoke, noise, altitude and temperature extremes. As a result,

since 1999, when the planning for any operation is initiated, strategic intelligence resources are dedicated to allow information gathering aimed at identifying potential EIHH and PHC. Identification of potential activities and an assessment of facilities or devices that may be hazardous or may cause contamination are made to determine if they could pose a threat to CF personnel. The assessment takes into account different exposure scenarios ranging from health hazards created during the peacetime operation of industrial sites to those created as a result of conflict. By assessing the suspected potential threats, commanders are able to determine what areas should be further examined and characterized. To accomplish this task, multidisciplinary teams of preventative medicine, environmental engineer, NBC (nuclear, biological, chemical) and intelligence personnel are grouped together to provide deployed commanders with competent specialist expertise. Since the creation of the EIHH/PHC Risk Framework, several successful environmental studies have been conducted, which has identified and mitigated potential health risks to Canadian Forces. This risk framework will not eliminate all risks to CF personnel involved in contingency operations but will help in identifying and reducing the risks posed to soldiers by protecting them from exposure to hazards that may be detrimental to human health, both over the short and long term.

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KEYWORDS

Forensic Investigation, Croatia, Deployed Operations, Environmental, Contaminants, Risk Assessment

Table 1a: Screening analysis

Inorganic Analyses	Analytes	Organic Analyses	Analytes
ICP	Aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, silver, sodium, strontium, sulphur, titanium, vanadium, and zinc	ABN	polycyclic aromatic hydrocarbons, phenols, chlorinated hydrocarbons, and phthalates
NAA		GC/MS	polychlorinated biphenyls (PCBs), chlorinated pesticides. organic compounds
AAS	lead, chromium and cadmium	Energetics	RDX, HMX, and TNT
		Pesticides	organophosphates triazine-like herbicides phenoxyacid herbicides
		Chemical Warfare Agents	common chemical warfare agents including: methylphosphonofluorid ates, tabun, VX, and mustard

Table 1b: Specific analysis

Inorganic Analyses	Method	Organic Analyses	Method
Arsenic (As)	hydride generation AAS	PCBs	GC-ECD
Mercury (Hg)	cold vapour atomic absorption	Dioxin/ Furans	High resolution GC-MS
Hexavalent chromium (Cr^{+6})	colorimetric and reagent	PAHs	GC-MS

Table 2: Analytical results

Element	Analytical Results (mg/kg)	Human Health-Based Soil Quality Guidelines (mg/kg) [a]
Aluminum, Al	1370 - 260350	-
Antimony, Sb	0.3 - 16.5	20 [b]
Arsenic, As	0.7 - 149	12
Barium, Ba	<5 - 137	500
Cadmium, Cd	<1 - 23.9	14
Calcium, Ca	1300 - 475000	-
Chromium, Cr	<5 - 2269	220
Cobalt, Co	<10 - 14.3	50 [b]
Copper, Cu	<5 - 106	1100
Iron, Fe	1200 - 248000	-
Lanthanum, La	4.4 - 178	-
Lead, Pb	<10 - 142	140
Magnesium, Mg	900 - 61500	-
Manganese, Mn	<15 - 3674	-
Mercury, Hg	<0.1 - 0.3	6.6
Nickel, Ni	<5 - 460	100 [b]
Potassium, K	<500 - 6400	-
Sodium, Na	500 - 15600	-
Strontium, Sr	8.4 - 276	-
Uranium, U	1.9 - 12	-
Vanadium, V	<5 - 1068	200 [b]
Zinc, Zn	<5 - 254	500 [b]
Dioxins/Furans (TEQs) [c]	1.6×10^{-9} - 1.0×10^{-6}	1.0×10^{-3} [b]

a - Canadian Environmental Quality Guidelines (CCME, 1999), except where noted;

b - Interim Soil Quality Guidelines (CCME, 1991);

c - Concentrations of dioxins/furans reported as toxic equivalents (TEQs) to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin; data on typical concentrations in soil from OMEE (1994).

Map 1: Canadian locations during OP harmony